

CARABIDAE AND STAPHYLINIDAE OF TWO FOREST RESERVATIONS  
AND THEIR REACTIONS ON SURROUNDING HUMAN ACTIVITY

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There are analyzed reactions of *Carabidae* and *Staphylinidae* of surrounding human activity in two forest reservations of Central Bohemia in present paper. It is shown that the clear cutting of a forest in neighbourhood of a reservation can influence its fauna in large extent towards the interior of the reservation. The reservation and economic beech forest of natural character have approximately identical carabids and staphylinids fauna. This fauna reacts on the thinning a forest by quantitative changes of its structure, but it is capable to renew the original structure during only one year. The border between a natural forest and a norway spruce monoculture is rather distinctive. The mutual influencing of both faunas is non-significant. So the economic forest of natural character or an artificial monoculture are acceptable in neighbourhood of a forest reservation if clear cutting is excluded. A sufficiently wide protective zone should be considered necessary, if the clear cutting in the vicinity of a reservation is inevitable. The algorithm for estimating the width of such zone is given.

One of the most important requirements of nature protection at present is the search of such methods which would enable the effective protection of living beings without excessive limiting economic and social functions of productive landscape. The precondition is, however, the knowledge of sensibility and of reactions of organisms on various kinds of human activity in the surrounding. The aim of the present paper is to point to some of such reactions in *Carabidae* and *Staphylinidae* in two forest reservation near Křivoklát (Brdsko-džbánská vrchovina highland in Central Bohemia) and in their surrounding stands underlying normal forest management.

## Material and methods

The pitfall trapping was applied for sampling the beetles. The glass jars (1 liter, 95 mm in diameter) with 4 % formalin and tin troughs (1000×100×50 mm), (Šustek, 1983) without fixative solution were used as the traps. Both types of traps were set 30 m from each other in the transects crossing the reservation and neighbouring

stand. On the border of reservation and in two nearest points of the transect, the tin troughs were doubled for distinguishing the direction of migration. The distance of jar and trough in each point was about 1.5 m. The beetles dropped into traps were taken in one month intervals. The material was sampled during whole vegetation period 1978 and 1979.

One transect (13 jars, 10 simple and 3 double troughs) was situated in the reservation of Malá Pleš near Karlova Ves near Křivoklát in Central Bohemia. It crossed an approximately 100 years old oak-beech stand and clear cutting. The stand was situated in the elevation of 350–450 m on the western scree. The shrub stratum was absent. The insularly developed herbage stratum was dominated by *Urtica dioica*, *Asperula odorata* and young *Acer platanoides*. Phytocenologically, the stand was close to *Quercus Fageta*. The stand arised on large clearing, where charcoal was burned. The closely neighbouring clearing sprung up during winter 1977/8. Its more distant central part was yet covered by 5–7 years old culture of norway spruce and beech, while the opposite side by individually dispersed 10–15 years old norway spruce.

The second transect (14 jars, 8 simple and 6 double troughs) was situated in the reservation Kohoutov near Ostrovec. It was divided into two parts. The first part (traps 1–7) crossed the reservation of 150–200 years old beech stand and the neighbouring economically exploited 80 years old beech stand without shrub stratum and with only sporadic *Asperula odorata*. Phytocenologically both stands were close to *Fagus paupera*. The second part (trap 8–14) crossed the last stand and the approximately 60 years old norway spruce monoculture. All stands were situated on moderate south-eastern slope at elevation of 480–500 m. All stands in Kohoutov arised artificially on large clearings, where the charcoal was burned during an extended period of last century. The economic stand was thinned during the winter 1977/8 and the timber has been picked up during whole summer.

The similarity of the samples was evaluated by Jaccard's index of similarity and by Renkonen's index of dominance identity. The group average method was used for the cluster analysis of results. Shannon-Wiener formula was used for evaluation of alpha-diversity of the samples. The lognormal distribution was applied for the description of quantitative structure of the communities. The species represented by 5–10 % individuals are considered dominant, 2–5 % subdominant, 1–2 % recedent and less than 1 % influent.

### Species spectra and their structure

4715 individuals of Carabids were sampled belonging to 35 species as well as 711 individuals of Staphylinids belonging to 34 species during 1978 and 1979. The whole material consists of 5426 individuals and 69 species.

The review of species, their abundance, frequency and dominance in individual traps and parts of the transects is given in tab. 1–4. The species spectrum in Malá Pleš was richer than in Kohoutov. Similarly, the samples from classical traps are richer than from troughs due to large volume of the troughs, which made it impossible to use an adequate fixation solution, because of their large volume. So the beetles dropped into troughs could leak out easier than from the traps.

The carabids *A. ater*, *C. nemoralis* and *P. burmeisteri* were dominant in all transects. The staphylinide *Z. humeralis* was dominant on clearing in Malá Pleš, where a colony of *Formica rufa* was found in the vicinity of the traps 12–13 (tab. 2), where it lives like a synechter.

Table 1  
Activity abundance of Carabidae and Staphylinidae in individual troughs in Malá Pleš and their dominance and frequency in individual parts of the transect

Species	Trough													Reservation												Clearing												De %	Dc %	Fr	Fcl																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	1	2	3	4	5	6	7A	7B	8A	8B	9A	9B	10	11	12	13	8B	9A	9B	10	11	12	13																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
<i>Abax ater</i>	9	10	20	14	32	81	22	53	18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

[R = reservation, CL = clearing, D = dominance, F = frequency].

Table 2

Activity abundance, dominance, frequency and distributional ranges of arachnids and Staphylinidae in individual traps in Malá Ples and in individual parts of the transect

Species	Trap	Range	Reservation													Clearing					Dr %	Dc %	Fr	Fcl
			1	2	3	4	5	6	7	8	9	10	11	12	13									
<i>Philonthus decorus</i>		W	44	30	28	26	27	20	2	4						1	1	9	3	11	10.5	0.4	22.8	0.2
<i>Abax ater</i>		W	11	10	22	27	36	21	3	2						1	1	3	1		13.5	1.0	16.5	5.0
<i>Pterostichus burmeisteri</i>		CE	15	46	14	10	17	6	10	0	10	3	1			10	3	1			12.7	4.0	15.5	4.0
<i>Carabus hortensis</i>		W	11	6	8	16	5	4	4		8	3	9	27	15	8	3	9			5.7	24.9	7.0	7.8
<i>Ocyrops tenebrioides</i>		CE	11	13	14	9	20	27	1	1						5	2	1	1	1	9.4	2.0	12.0	1.0
<i>Carabus nemoralis</i>		E	6	5	12	5	38	1	2	1						5	1	1	2		7.1	3.2	9.0	1.6
<i>Carabus coriaceus</i>		E	7	4	11	10	14	7	1	11						7	2	2			6.0	4.4	0.1	1.2
<i>Philonthus laeviellus</i>		CE	4	11	5	10	12	9													5.2		0.4	
<i>Pterostichus oblongopunctatus</i>		T	12	15	7	4	7														4.7		5.7	
<i>Tachinus rufipes</i>		T	9	5	3	2	1														2.2	1.6	2.9	0.8
<i>Zyrus humeralis</i>		T																			1.3	0.8	4.4	
<i>Amara ovalis</i>		ES	9			1	2	1	1	1						1	3				1.4	1.6	1.8	0.8
<i>Pterostichus niger</i>		T																			0.2	0.6	0.3	3.0
<i>Abax ovatus</i>		CE																			1.5		1.9	
<i>Carabus aeneus</i>		CE	1	10	1	1	1	1	3	4											1.5		0.9	
<i>Ocyrops platyommis</i>		P	1	7	1	2	3	1	1	3						1	2		1		1.4	1.6	1.3	0.8
<i>Harpalus punctulatus</i>		W	1	1	2	1	2	1	2		6					1					1.0	1.6	1.8	0.4
<i>Cychrus affinis</i>		W									1					1					0.6	0.8	0.8	0.4
<i>Amara urnea</i>		ES	1	1	1	1	1	2								2	4	1	1		0.3	1.4	0.4	0.8
<i>Molops elatus</i>		CE														2	2	3	2		0.1	2.4	0.1	1.2
<i>Carabus aeneus</i>		W																			0.1	2.6	0.1	1.4
<i>Bombidion lampros</i>		ES	1																		0.1	0.2	0.1	1.0
<i>Othius myrmecophilus</i>		E																			0.2	0.2	0.2	0.2
<i>Brachycollus collaris</i>		ES				1	1				1					2				1	0.3	1.2	0.4	0.6
<i>Harpalus latus</i>		ES	1	1	1	1	1	1													0.4	0.8	0.5	0.4
<i>Nothophilus biguttatus</i>		T	1	1	1	1										1	1	1	1		0.2	1.2	0.3	0.8
<i>Xantholinus tricolor</i>		T	1	1	1	1										2	1	1	1		0.2	1.2	0.3	0.8
<i>Amara lamellaris</i>		ES														2	1	1	2		0.2	1.2	0.3	0.8
<i>Pterostichus ovolepis</i>		W														2					0.2	2.0	0.5	1.0
<i>Molops piceus</i>		CE	1	1	1	1	1	1	1	1											0.5	0.8	6.1	0.4
<i>Pterostichus melis</i>		W																			0.2	0.8	0.3	

{R = reservation, Cl = clearing, D = dominance, F = frequency, H = holarctic, T = transpalearctic, W = westpalearctic, E = european, CE = central-european, ES = euroasiatic, C = cosmopolitan, F = panpalearctic}.

<i>Atheta sp.</i>	7																			
<i>Harpalus ruficornis</i>	ES																			
<i>Trichostichus lamellatus</i>	CE																			
<i>Harpalus aeneus</i>	SE																			
<i>Staphylinus coarctatus</i>	H																			
<i>Philonthus lineatus</i>	T																			
<i>Staphylinus chalcidophilus</i>	W																			
<i>Pterostichus uliginosus</i>	W																			
<i>Oxytelus parvipes</i>	F																			
<i>Oxytelus fulvipes</i>	H																			
<i>Bryochorus claviger</i>	ES																			
<i>Harpalus latus</i>	H																			
<i>Omatium rivulare</i>	F																			
<i>Aleochara sp.</i>	T																			
<i>Pterostichus arenarius</i>	T																			
<i>Harpalus ruficornis</i>	ES																			
<i>Harpalus ruficornis</i>	W																			
<i>Drusilla emarginata</i>	T																			
<i>Xantholinus lineatus</i>	T																			
<i>Staphylinus fossor</i>	E																			
<i>Lacinius hollmanni</i>	CE																			
<i>Gyrogonus fracticornis</i>	C																			
<i>Oxytelus similis</i>	W																			
<i>Galasema inquisitor</i>	T																			
<i>Bryochorus lineatus</i>	W																			
<i>Aleochara curculio</i>	H																			
<i>Philonthus politus</i>	C																			
<i>Leptus piceus</i>	CE																			
Number of individuals		149	184	124	124	124	217	105	37	40	52	23	30	81	55	380	249			
Number of species		15	32	10	10	25	14	12	13	15	10	16	23	12	43	337	38			
H' (bit)																3.37	3.19			

Tab  
Activity abundance of Carabidae and Staphylinidae in individual traps in Ko

Species	Trap	Res			Econ. Stand			
		1	2	3	4	5	6	7
<i>Pterostichus burmeisteri</i>		93	53	100	71	97	70	52
<i>Abax ater</i>		37	7	13	11	20	39	28
<i>Carabus auronitens</i>		24	4	18	25	21	16	7
<i>Carabus nemoralis</i>		25	1	6	8	12	18	7
<i>Philonthus decorus</i>		32	9	28	4		2	
<i>Lathrobium atrocephalum</i>			1				39	
<i>Pterostichus oblongopunctatus</i>		1	2	28	1	1	2	
<i>Abax ovalis</i>			2	9	1	2	6	
<i>Carabus coriaceus</i>		2		1		5	3	
<i>Carabus hortensis</i>		1	2		1	5	1	
<i>Ocyopus tenebricosus</i>		2	1	1	2		1	
<i>Othius punctulatus</i>				5			1	
<i>Philonthus varians</i>			1		1	1		
<i>Molops piceus</i>		1					1	
<i>Atheta sp.</i>				2				
<i>Ocyopus fuscipes</i>							1	
<i>Xantholinus tricolor</i>			1					
<i>Othius myrmecophilus</i>						1		
<i>Lathrobium bruneum</i>				1				
<i>Amara aenea</i>								
<i>Pterostichus melas</i>								
<i>Carabus arcensis</i>								
<i>Notiophilus biguttatus</i>								
<i>Quedius mesomelinus</i>								
<i>Calosoma inquisitor</i>								
<i>Staphylinus fossor</i>								
<i>Omalium rivulare</i>								
<i>Pterostichus niger</i>								
<i>Harpalus ruficornis</i>								
<i>Abax parallelus</i>								
<i>Carabus glabratus</i>								
Number of individuals		218	84	212	123	165	200	92
Number of species		10	12	12	10	10	14	4
H' (bit)								

(Res. = reservation, Econ. Stand = economic stand, Mon. = norway spruce monoculture, D = dominance, F = frequency).

The carabids *C. hortensis* and *C. auronitens* were dominant or subdominant. The higher frequency and dominance in *C. hortensis* on clearing in Malá Pleš and in the norway spruce monoculture in Kohoutov is due to higher ecological tolerance of *C. hortensis* to changes in stand structure and due to the excluded competition of less tolerant species. Higher dominance and frequency in *C. auronitens* in Kohoutov is due to colder microclimate, higher elevation and north-eastern situation of sampling sites. Similarly, in Malá Pleš *C. auronitens* concentrates in the highest parts of reservation (traps 1–3). The optimum vertical distribution in *C. auronitens* was found in fir-beech and norway spruce-fir-beech vegetation tier.

*Carabus coriaceus* was dominant in Malá Pleš and recedent in Kohoutov due

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houtov and their dominance and frequency in individual parts of the transect

Econ. Stand			Mon.				Dr	Des	DES	DMON	FR	FES	FES	FM
6	9	10	11	12	13	14								
42	20	49	2	1	1	4	47.9	50.0	36.9	5.5	80.4	72.7	32.0	2.0
16	23	40	1	1	12		11.0	16.5	22.1	11.7	17.9	25.9	4.3	24.0
6	4	4	2				8.9	11.9	3.9	1.4	16.7	16.1	4.7	0.5
9	1	5	4	2	2	1	6.2	7.4	4.2	6.2	10.0	11.4	5.0	2.3
15	12	10					13.4	1.0	10.3		20.9	0.9	12.3	
							0.2	6.7			0.3	11.1		
13	17	11	3	1	1		6.0	0.7	11.4	3.5	9.0	1.0	13.7	1.2
1							2.1	1.6	0.6		3.3	2.4	0.7	
							0.6	1.4	0.6	0.7	0.9	2.3	0.7	0.3
8		5	16	50	24	6	0.6	1.2	3.6	66.2	1.0	1.9	4.33	24.0
10	1	3					0.8	0.5	3.9		1.1	0.9	4.7	
1							1.0	0.2	0.3		0.9	0.3	0.3	
							0.2	0.3			0.4	0.4		
							0.2	0.2		0.7	0.3	0.3		0.3
			1				0.4		0.6	0.7	0.6		0.7	0.3
			2					0.2				0.3		
							0.2	0.2	0.3		0.3		0.3	
							0.2	0.2			0.3			
	5	2					0.2		1.9				2.3	
1	5							1.7					1.7	
	2							0.6		1.4			0.7	0.5
			1	1	1					2.1			0.8	
3									0.8				1.0	
1	2							0.8					1.0	
1	1							0.6		0.7			0.7	0.2
			2					0.6					0.7	
										0.7				0.2
										0.7				0.2
1									0.3				0.3	
	1								0.3				0.3	
128	95	136	34	58	42	11	514	580	359	145				
15	14	13	12	8	7	3	17	16	22	13				
							2.14	2.13	2.94	1.68				

to warmer microclimate in Malá Pleš. It occurred in less changed parts of both localities, similarly as *P. oblongopunctatus* and *P. decorus*. The occurrence of *P. decorus* was influenced also by its preference to high humidity. Its sporadic occurrence in thinned economical beech stand indicated the decrease in humidity after its cleaning.

The carabide *C. attenuatus* and staphylinids *O. tenebricosus* and *T. rufipes* were recedent or subrecedent. They seem to exhibit a low tolerance against anthropogenous changes. The carabid *A. ovalis* occurred only in the reservations and in economic beech stand, while it was absent in clearing and in norway spruce monoculture.

The carabids *C. arcensis*, *M. elatus*, *A. aenea*, *P. niger*, *B. lampros*, *B. collaris* and *P. ovoideus* and staphylinids *T. laeviusculus* and *O. myrmecophilus* were

Activity abundance of Carabidae and Staphylinidae in individual troughs in Ko

[illegible]

[Res. = reservation, Econ. Stand = economic stand, Mon. = norway spruce monoculture, D = dominance, F = frequency].

subdominant in the clearing of Malá Pleš. They occurred sporadically in all other parts of transects. The subdominant representation of these species is to be considered only as occasional. The generally low abundance in all species in clearing leads to relatively high values of dominance even in species represented by few individuals. The species *A. aenea*, *B. lampros* and *B. collaris* are typical inhabitants of cultural steppe or of open areas in general. They penetrate clearing after the forest was cut and they would occupy it, if the clearing were not afforested in time. Their occurrence in the clearing indicates the initial stage of succession between forest and cultural steppe. The staphylinids *O. myrmecophilus* and *T. laeplussculus* are mesohygrophilous with a certain preference for forest habitats. They occur in clearing more or less occasional.

The carabids *P. melas*, *A. ovata*, *H. latus*, *N. biguttatus*, *A. familiaris*, *C. glabratus* and *C. inquisitor* and staphylinids *O. picipennis* were recedent or influent. The carabids *P. melas*, *C. glabratus*, *C. inquisitor* and staphylinids *O. punctulatus* and *X. tricolor* are characteristic of forests, while *A. ovata*, *A. familiaris* and *H. latus* are typical of cultural steppe. The carabide *N. biguttatus* prefers coniferous stands. The remaing forty species were always influent (tab.

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[illegible]

1—4). The carabids *C. convexus*, *A. parallelus*, *M. piceus*, *L. hoffmansegi*, *L. piceus*, *P. strenuus*, *P. aethiops*, *T. laevicollis* are representatives of forest fauna in highlands. *Abax parallelus* is euryecous. The staphylinids *L. bruneum*, *P. parvus*, *B. lunulatus*, *O. similis*, *O. rivulare* and *B. cingulata* are relatively eurytopic with a limited preference for afforested habitats. On the contrary the carabids *C. campestris*, *H. tardus*, *H. ruficornis*, *H. rufibarbis*, *H. aeneus*, *P. cupreus*, *P. vulgaris*, *S. nivalis*, *B. bipustulatus* are characteristic of cultural steppe or of open landscape in general. *P. vulgaris* is eurytopic. The staphylinids *S. fossor*, *S. caesareus*, *S. chalciocephalus*, *P. politus*, *P. fimetarius*, *G. fracticornis*, *X. linearis*, *Q. paradistanus*, *Q. mesomelinus*, *L. atrocephalus*, *D. canaliculata*, *R. rufipes* and *A. curtula* are eurytopic species occurring in forests and cultural steppe as well.

A suitable model of structure of a community is the log-normal distribution. In the natural communities (fig. 1) the 6-8th octaves are occupied by 2-5 species and the standard deviation is large, while on the clearing and in the norway spruce monoculture majority of the species is concentrated in 0-2nd octave and the standard deviation decreases. This pattern indicates the governing the whole community by only more tolerant species on the clearing and in the monoculture. The communities in the reservation are governed by a larger number of mutually competing species.



Communities in individual parts of transects studied and their classification within the frame of natural and influenced geobiocenoses of Moravia and Bohemia

The communities from Malá Pleš and Kohoutov form two separate clusters according to their species similarity. Both clusters associate with each other and together they associate with clusters of communities from fir-beech forests, oak-beech forest and pine monocultures in similar elevation. Together with all above communities they form a very low-level similarity clusters with communities in oak up to oak-beech vegetation tier. All these communities are characterised by the simultaneous occurrence of species having wide vertical distribution (*A. ater*, *C. nemoralis*, *C. corlaceus*, *O. tenebrioides*, *P.*

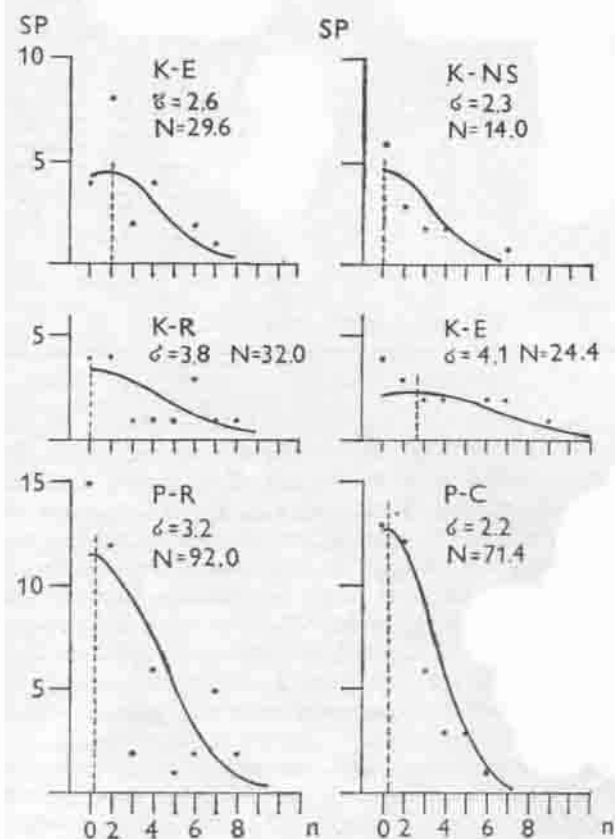


Fig. 1. Log-normal model of community structure of *Carabidae* and *Staphylinidae* in individual parts of the transects in Malá Pleš (P) and Kohoutov (K), (R = reservation, C = clearing, E = economically exploited beech stand, NS = norway spruce monoculture, SP = number of species in individual octaves, n = number of octave — binar logarithmus,  $\sigma$  = standard deviation, N = theoretical number of species, dotted line = modal octave).

*decorus*, *X. tricolor*, *O. punctulatus*) and by species *P. burmeisteri*, *C. auronitens* and *C. attenuatus* having their optimum in beech to norway spruce-fir-beech vegetation tiers. The similarity between the communities of Malá Pleš and Kohoutov and the communities of oak and oak-beech vegetation tiers and of lowland forests is rather low.

The rise of two separate clusters for the communities from Malá Pleš and Kohoutov is due to the richer species spectrum in oak-beech stand and in clearing in Malá Pleš. Externally surprising rise of cluster of pine monoculture and oak beech forest is due to the simultaneous occurrence of *A. parallellus* in both geobiocenoses and due to its absence in Malá Pleš and Kohoutov and, finally, due to absence of Carabids *A. ovalis* and *C. auronitens* in pine monoculture and oak-beech forest. The low similarity level, however, indicates the free relationship between them.

According to the dominance identity, the communities from both localities studied form strikingly separated clusters. The first cluster is formed by communities from the clearing in Malá Pleš, from norway spruce monoculture in Kohoutov and from pine monoculture near Kosova hora. The second cluster is formed by communities from both reservations and economic beech forest. The former cluster associates with the cluster of communities from fir-beech forests (AF 5, AF 6) and oak-beech forest (QF 3), (fig. 2). The common cluster of these communities associates with the cluster of communities from anthropogenously influenced forests and finally with the clusters of other compared communities of oak up to oak beech vegetation tiers and on alluvia. These three clusters associate with each other on rather low level of similarity. The striking separation of communities from natural stands from those from anthropogenously changed forests indicates deep changes in their quantitative structure and in the representation of individual species. The species having higher ecological tolerance hold their abundance and dominance (e.g. *C. nemoralis*) under such condition or their abundance increases (*C. hortensis*) even due to the limiting of competition of other less tolerant species. A certain degree of preference for such conditions is observable in some of them (*N. biguttatus*). However, the majority of species does not suffer from such changes and they drop to a level of influent species or they disappear completely (*C. auronitens*, *C. attenuatus*, *P. burmeisteri*, *O. tenebrioides* etc., tab. 1—4).

The association of samples from both parts of economic beech forest in Kohoutov with the cluster of communities from natural stands indicates that the clear cutting had probably no considerable effect on the species spectrum and its structure in *Carabidae* and *Staphylinidae*.

The comparison of carabid and staphylinid communities in Malá Pleš and Kohoutov and in neighbouring economic beech stand are inhabited, contrary to their artificial origin, by relatively natural communities similar to those in compared natural forests in beech to norway spruce-fir-beech vegetation tiers.

Classification of carabid and staphylinid communities in individual traps of transects in Malá Pleš and Kohoutov

The samples from Malá Pleš form two distinct clusters. The first cluster is formed by samples from the interior of the reservation (traps 1—9) (fig.

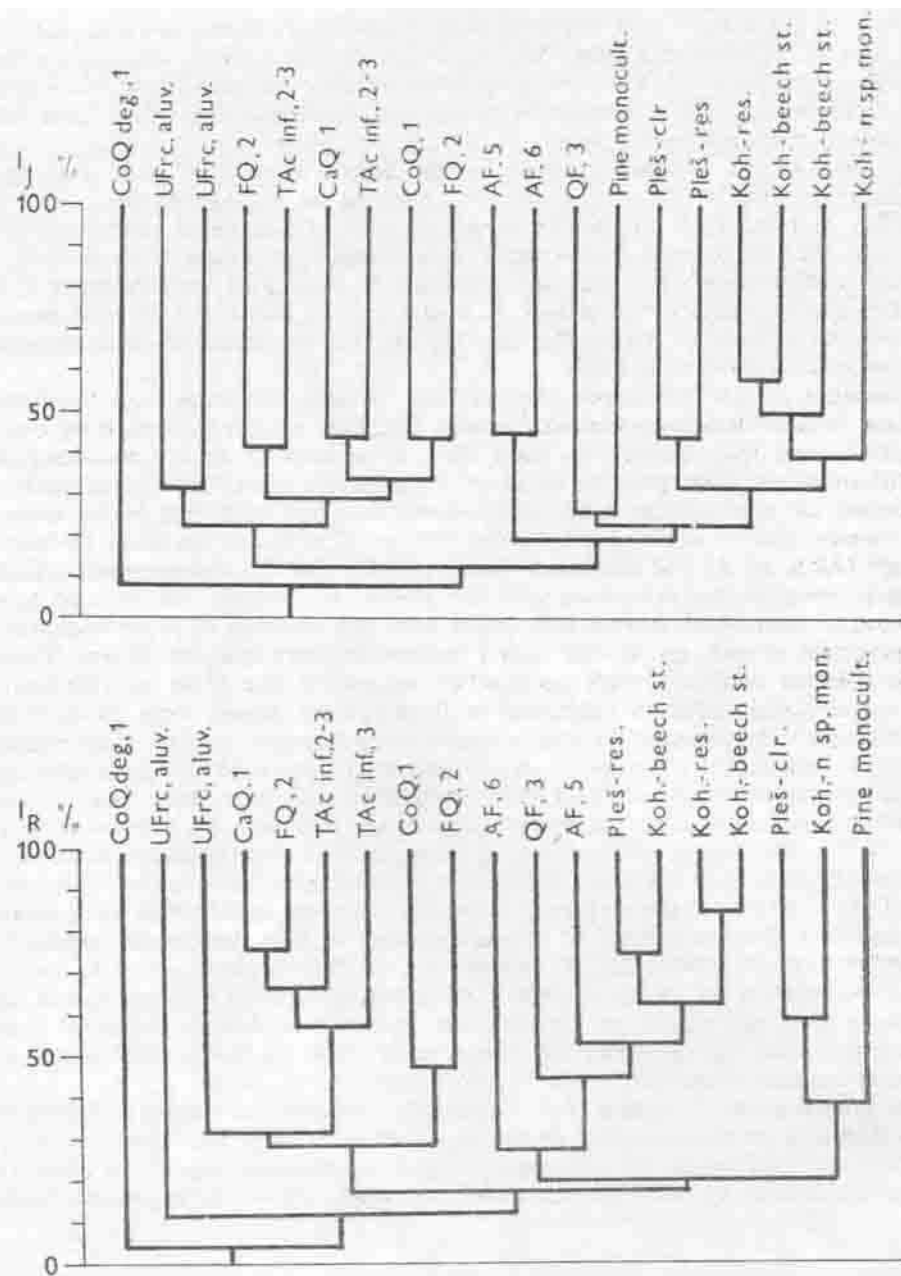


Fig. 2. Clustering of the carabids and staphylinids communities from individual parts of transects in Malá Pleš and Kohoutov and several forest geobiocoenoses in Moravia and Bohemia according to their species similarity ( $I_j$ ) and dominance identity ( $I_a$ ). [CoQ deg. = *Cornu Querceta* degr. stadium, oak veg. tier; FQ = *Fagi Querceta*, beech-oak veg. tier; CaQ = *Carpini Querceta*, oak veg. tier; TAc = *Tiliae Acereta*,

3]. In the frame of the first cluster a more homogenous cluster is formed by samples from the proper interior of reservation. The samples from the traps close to the margin of the stand associate gradually with this cluster.

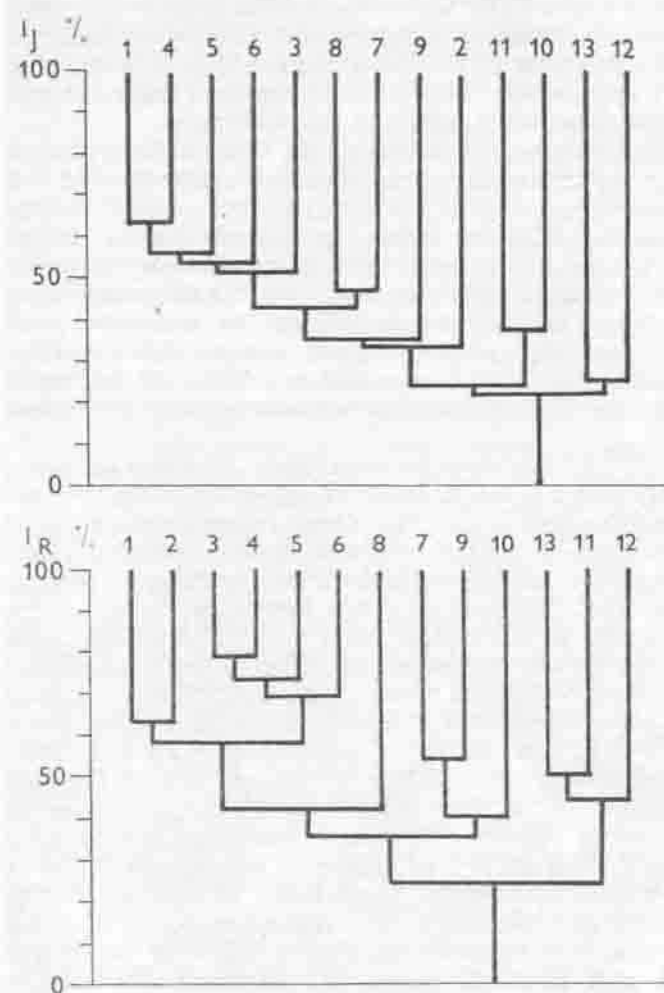


Fig. 3. Clustering of the samples from individual troughs from the transect between reservation (numbers 1-8) and clearing (numbers 8B-13) in Malá Pleš [ $I_j$  = Jaccards index of similarity,  $I_a$  = Renkonens index of dominance identity].

beech-oak to oak-beech veg. tier; QF = *Querci Fageta*, oak-beech veg. tier; AF = *Abieti Fageta*, fire-beech and norway spruce-fire-beech veg. tier; UFrc = *Ulm Fraxineta carpinea*, aluvia; res. = reservation; clr = clearing; n. sp. mon. = norway spruce monoculture; beech st. = economic beech stand;  $I_j$  = Jaccards index of similarity,  $I_a$  = Renkonens index of dominance identity],

According to dominance identity, three clusters are formed in the dendrogram. The first cluster corresponds to the traps 1—6 in the interior of reservation, the second corresponds to the traps 7—10 in the interior of reservation, the third corresponds to the traps 11—13 in the interior of the clearing. An intermediate position is occupied by trap 8. The described tendency gets even more striking in the troughs, where these three clusters are obvious from the classification after dominance identity and species similarity as well. The troughs 1 and 2 represent an exception because they were destroyed sometimes by wild boars and so they associate spontaneously with the poorer samples from the troughs close to the margin of the reservation.

The mutually corresponding clustering of samples from traps and troughs indicates their separation into samples characteristic for the interior of the reservation, its margin and of the clearing. The gradual association of the traps from clearing with the remaining ones reminiscent of „chain effect“ indicates, in this case, that the clearing misses any characteristic species spectrum. The clearing is inhabited mostly by the remnants of original forest fauna before clear cutting was started and by occasional emigrants from surrounding stands. The penetrating by species characteristic of cultural steppe is rather slow and the immigration is inhibited by large forest complexes isolating the clearing from the migrational resources of open landscape species.

The species *C. hortensis* occurs abundantly in the afforested part of the clearing. It represents a consequence of afforestation by norway spruce and a start of the succession towards the fauna characteristic of its monocultures in middle elevations. A quite different situation is found in Kohoutov. There the two clusters are formed in dendrograms by samples from normal traps and troughs as well. The first cluster is formed by samples from reservation and from both parts of economical beech forest. The second cluster is formed by samples from norway spruce monoculture. In the dendrograms of species similarity according to Jaccard's index, the samples from neighbouring or most close traps and troughs form the clusters. (e. g. troughs 5B—8, 10 B—11, traps 24—5, 8—9). This pattern of association is more evident from traps than from troughs. The same pattern is observed also in the dendrograms of identity dominance, in the traps and troughs as well. According to dominance identity the traps in interior of norway monoculture and on its margin can be distinguished. This pattern of clustering corresponds to the immigrations of beetles from biotically richer beech forest into the poorer monoculture.

The reservation and both parts of neighbouring economic beech forest are inhabited by fauna of Carabids and Staphylinids with rather similar species spectrum and with identical quantitative structure. The association of the samples from these three parts of the transects into common cluster indicates that the variability of individual samples is larger than the differences between the faunas in these segments of geobiotocenoses. The separation of the samples from the norway spruce monoculture is caused: 1. by a sudden decrease in abundance or by absence of majority of the species inhabiting the beech forest, 2. by persisting abundance in *C. nemoralis*, 3. by the increase in abundance in *C. hortensis* and *N. biguttatus*, (tab. 3—4). Also microclimatic factors inhibit the immigration. Such migration is more intensive between oak beech forest and clearing than between beech forest and norway spruce

monoculture. It is remarkable from the view of nature protection that such immigration does not exist in an inverse direction (tab. 3—4). It is obvious that the economic beech-forest offers a solid protection to the Carabids and Staphylinids in the reservation from the influences of its surrounding. The fauna in the beech forest has approximately the same biotic value as that one of the reservation. The distant border between the fauna in economic beech forest and in norway spruce monoculture indicates that from the view of model groups a reservation can neighbour with such artificial biocenoses.

#### Areographical characteristics of Carabidae and Staphylinidae in Malá Pleš and Kohoutov

In Malá Pleš the Westpalaearctic species predominate qualitatively and quantitatively in the species spectra. Less represented were the European and the Centraleuropean species. Their qualitative representation was higher than the quantitative representation. The sporadically occurring transpalaearctic species are represented better qualitatively than quantitatively in the forest, but their qualitative and quantitative representation is equal in the clearing. Similarly also Eurosiberian species are represented more in the clearing.

In Kohoutov, in the reservation and in beech stand, the quantitative representation of the dominant Centraleuropean species was higher than the qualitative one. The relation of qualitative and quantitative representation was inverse in westpalaearctic species. In the norway spruce monoculture only Westpalaearctic species occurred abundantly. Their quantitative representation was higher than the qualitative.

The predominance of Westpalaearctic and European species and low representation of species with other type of distributional ranges in Malá Pleš corresponds to the areographical structure of carabid and staphylinid communities in oak to oak-beech vegetation tier in Central Europe. The non-significant differences in areographical structure of species spectra in the reservation and clearing limited only to a slight nivelization of the quantitative and qualitative representation of Transpalaearctic species and a slightly increased representation of Eurosiberian species indicate that the remnants of original forest fauna survive on the clearing if it is surrounded by large stands. The immigration of cultural steppe fauna in which the Transpalaearctic and European species dominate, seems to be slow under such circumstances (cf. Šustek, 1983; Lauterbach, 1964; Broen, 1965).

The high representation of Centraleuropean species in the reservation and in the economic beech forest in Kohoutov, the decrease in representation of the Westpalaearctic species are a general phenomenon of vertical zonality of carabids in Central Europe. The more or less endemic species of Centraleuropean highland (*P. burmeisteri*, *C. auronitens*, *C. attenuatus*, *M. piceus* and *M. elatus*) are favoured in this higher and colder locality in comparison with the Westpalaearctic species inhabiting the forests in lower elevations of Western Palaearctis. The sudden decrease in occurrence of species of all distributional types in the norway spruce monoculture is due to generally poorer species spectrum in this monoculture. An other reason of this decrease is the



fact that the influenced geobiocenoses are inhabited by species, the distributional areas of which overlaps mostly with the distributional area of the biomes to which a geobiocenosis belongs. In this case, the beech stand turned into a monoculture is inhabited by the Westpalearctic species.

The striking difference between the areographical structure of carabids and staphylinids in reservation or in economic beech stand and in norway spruce monoculture on one hand and the negligible difference in areographical structure of reservation and clearing on the other hand indicate the existence of a wide ecoton between a reservation and a clearing and a distinctive border between a reservation (natural forest) and a artificial monoculture.

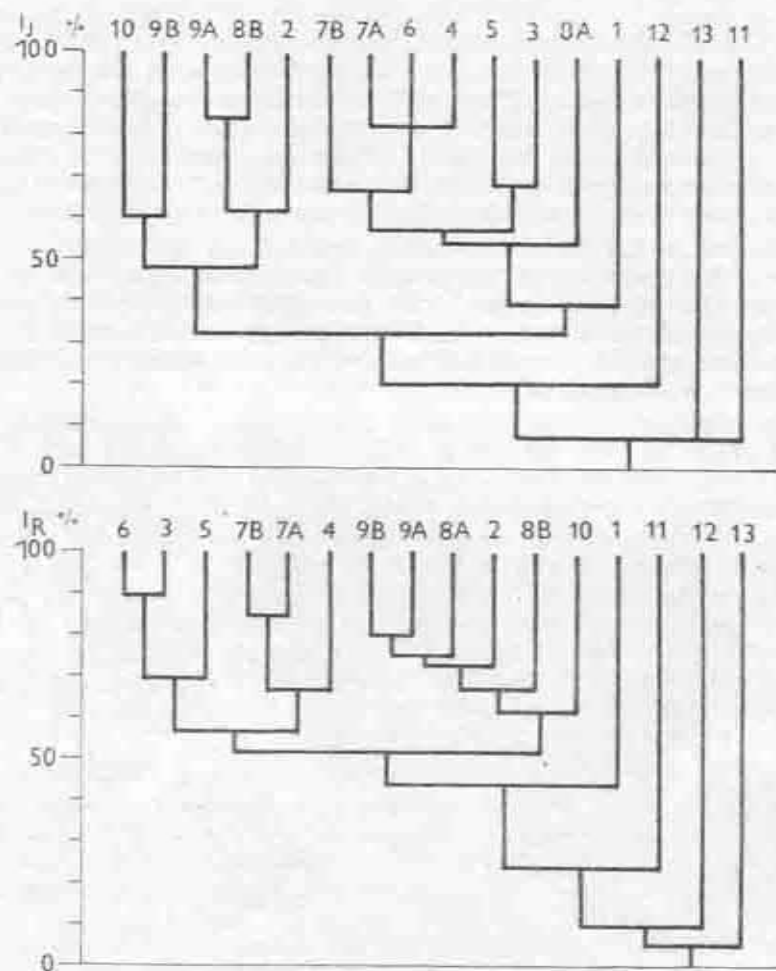


Fig. 4. Clustering of the samples from individual troughs from the transect between reservation (numbers 1 = 8A) and clearing (numbers 8B = 13) in Malá Pleš [ $I_j$ ,  $I_R$  = see fig. 3].

# Changes in alpha diversity of carabids and staphylinids along the transects in Malá Pleš and Kohoutov

Irrespective of the different sampling effectivity of both sampling methods, the carabids and staphylinids reach the largest number of species and individuals in the interior of the reservation. In Malá Pleš the species and individual numbers decrease towards the margin of the stand. The species and individual numbers observed on the margin keep the same level till the centre of the clearing and they start to increase slightly in its afforested part (fig. 8).

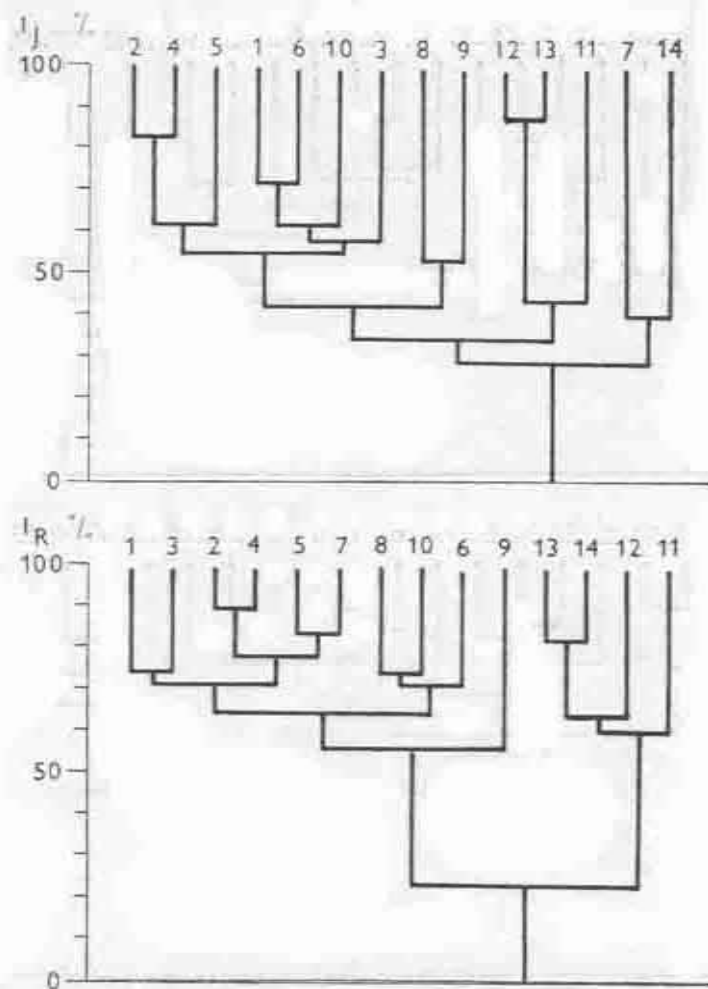


Fig. 5. Clustering of the samples from individual traps from the transect between the reservation of the beech stand (numbers 1-3), economic beech stand (numbers 4-10) and norway spruce monoculture (numbers 11-14) in Kohoutov [ $I_j$ ,  $I_R$  see fig. 3].

On the margin of the reservation the number of species and individuals is higher in the troughs open towards the interior of the reservation than in the troughs open towards the clearing (tab. 1, fig. 9). The same character shows the changes of alpha diversity (fig. 9). Contrary to the expectation the lowest values of alpha diversity were observed in the ecotone between the reservation and the clearing. The highest values are found in the interior of the reservation and in the afforested interior of the clearing. The low values of alpha diversity and low numbers of species and individuals are due to the back-reflexion of sun rays from the stems and crowns in the irradiated margin of

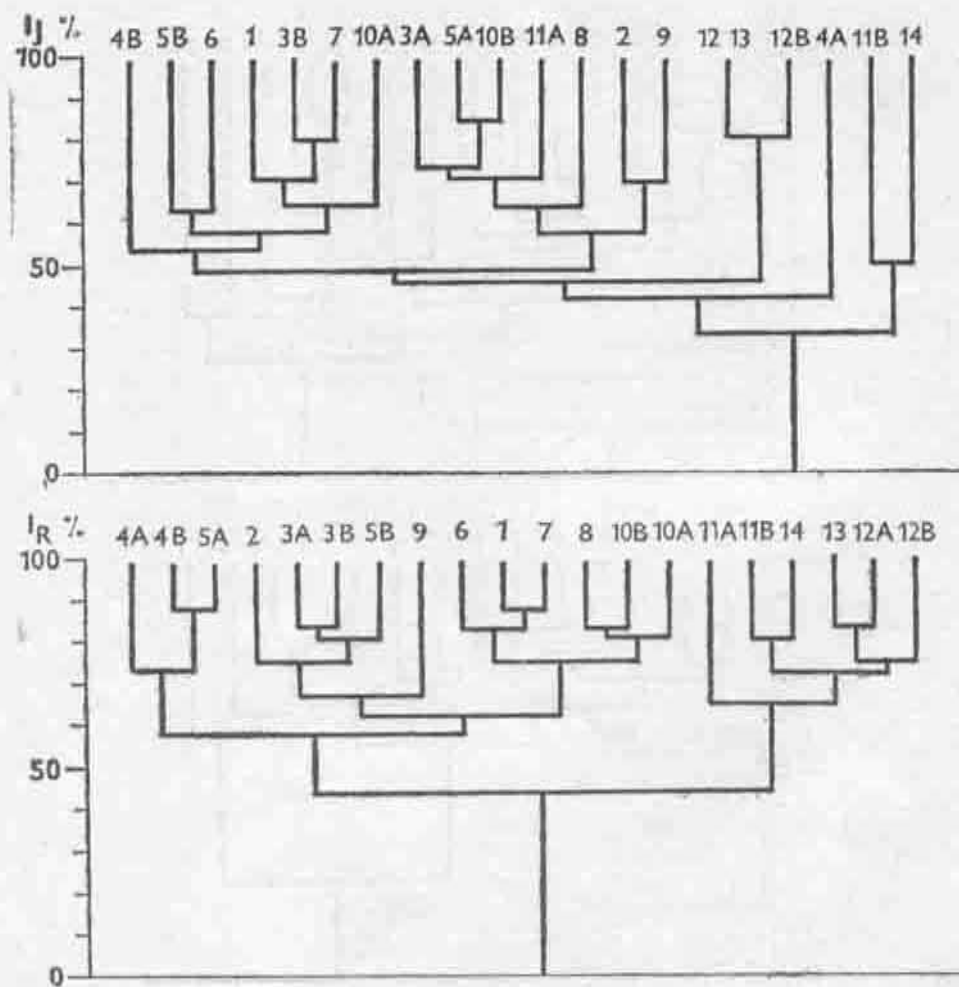


Fig. 6. Clustering of the samples from individual troughs from the transect between the reservation of the beech stand (numbers 1—4A), economic beech stand (numbers 4B—11A) and norway spruce monoculture (numbers 11B—14) in Kohoutov (I<sub>j</sub>, I<sub>k</sub> see fig. 3).

KOHOUTOV

KOHOUTOV

MALÁ PLEŠ



Fig. 7. Areographical structure of *Carabidae* and *Staphylinidae* in individual parts of studied transects (C = cosmopolitan, H = Holarctic, P = Palearctic, T = Transpalearctic, W = Westpalearctic, E = European, CE = Central-European, ES = Eurosiberian; Cl = clearing, R = reservation, Ec = economical stand, S = norway spruce monoculture, k = troughs, p = traps, black columns = percentage of individuals, white columns = percentage of species).

the stand. The temperature is in such condition even higher than in a fully insolated clearing (Krečmer, Fojt, 1967) and the humidity of soil surface drops considerably. So the unfavourable conditions are created for the forest carabids and staphylinids, which are represented mostly by mesohygrophilous species living in darkness (Thiele 1977 and other authors). Another reason for low alpha diversity values in the ecoton is the low beta diversity between carabids and staphylinids in the reservation and in clearing. The typical ecotonal community having large number of species from both neighbouring cenoses and, consequently, high alpha diversity can not arise in this case. The values of the alpha diversity in the interior of the reservation in Malá Pleš corresponds approximately to the alpha diversity of carabids and staphylinids in natural stand in Moravia during the sixties (Sustek, 1980, 1983). The decrease in alpha diversity of both model groups in the vicinity of a margin indicates that the clearing in the neighbourhood of a reservation can influence the fauna rather deeply even in its interior.

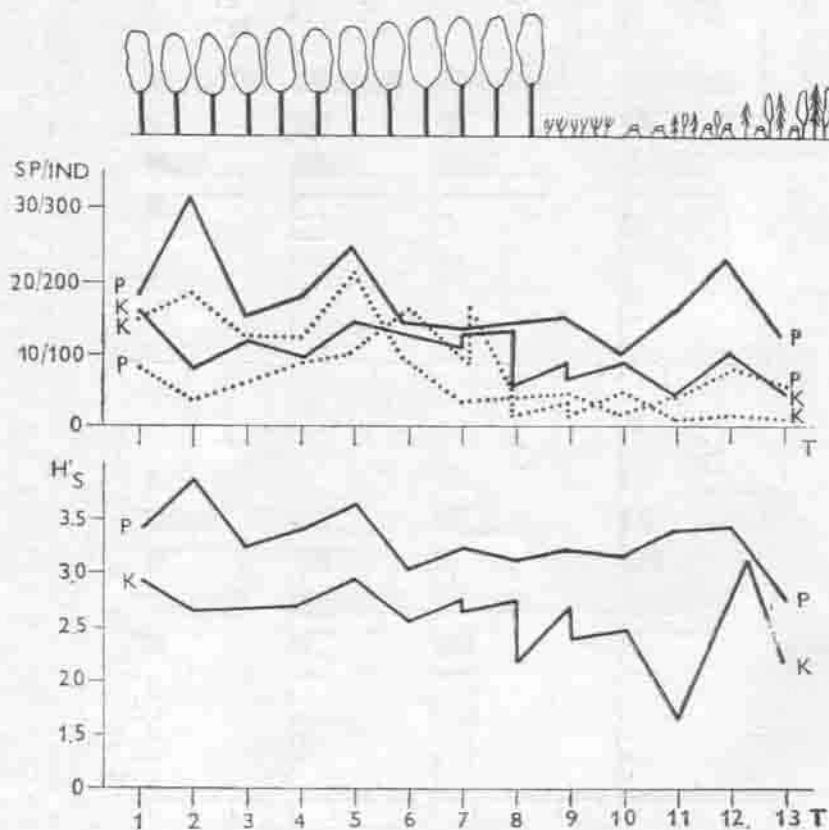


Fig. 8. Number of species (SP) and individuals (IND) and alpha-diversity in bits ( $H'$ ) in the transect between reservation and clearing in Malá Pleš (P = traps, K = troughs; T = number of trap or trough).

In Kohoutov, the number of species and individuals is approximately equal in the reservation and in both parts of economic beech stands. The numbers of individuals in troughs indicate that the beetles migrate even from the economic stands into reservation (tab. 3, fig. 9). Similarly, no considerable differences in alpha diversity were observed in these two stands. In some places, the alpha diversity is even slightly higher in the economic stand. In the border between beech stand and norway spruce monoculture the number of species and individuals and the value of alpha diversity decrease suddenly under levels observed in the reservation and in beech stand. The decreasing trend continues towards the interior of the monoculture. The numbers of individuals in troughs (tab. 3-4, fig. 9) indicate that the beetles migrate, in limited extent, from the beech stand into monoculture. Approximately equal values of species and numbers of individuals and values of alpha diversity in carabids and staphylinids of the reservation and of economic beech stand indicate that there is no considerable difference between both stands and that the economic beech stand can offer a reliable protective zone against several influences from the surrounding. The neighbourhood of a reservation and a norway spruce monoculture is acceptable too. The danger of influencing the fauna in a reservation seems to be negligible.

From the practical view the lower values of alpha diversity immediately after the clearing during 1977/8 and their increase during the following year, if compared with the equal values in reservation and monoculture during both years, are of a great importance. They indicate that the carabids and staphylinids

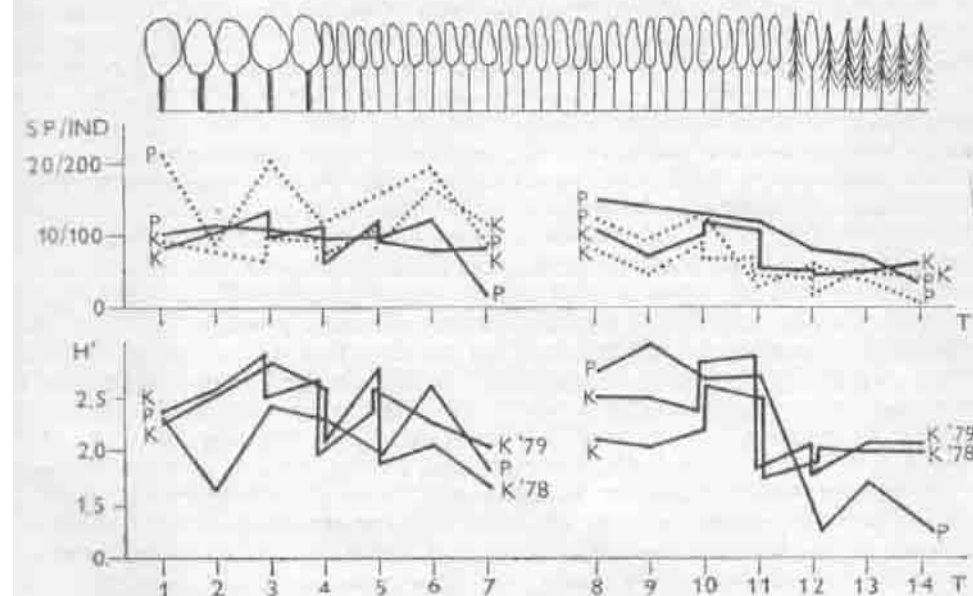


Fig. 9. Number of species (SP) and individuals (IND) and alpha-diversity in bits ( $H'$ ) in the transect between reservation and clearing in Kohoutov (P = traps, K = '78, K '79 = troughs from the year 1978 immediately after thinning and from the year 1979 one year after it, T = number of trap or trough.)

nids upon the clearing reacted by quantitative changes in the structure of their community, but in course of only one year they were capable to renew their original structure.

The alpha diversity in the interior of the clearing in Malá Pleš is twice larger than in the norway spruce monoculture in Kohoutov. It is due to the generally low numbers of individuals in the clearing, which leads to rather balanced representation of all species (Šustek, 1980). The initial stage of the succession towards the faunula of cultural steppe plays only a limited role in this case due to a limited penetration by cultural steppe species.

## Discussion

All above analyses show conformly that there are no important differences in the communities of Carabidae and Staphylinidae between a protected and between an exploited beech stand. The communities in the exploited stands are even richer than in the protected sites. This can be interpreted as a consequence of the approximation of the protected stand to the climax. The change in the communities in the border of a beech stand and a norway spruce monoculture is rather sudden. The community in the monoculture is enriched by the slight migration from beech stand. The occurrence of *C. hortensis* in all parts of the transects, its higher abundance in the norway spruce monoculture in Kohoutov and in the afforested part of the clearing in Malá Pleš, and the absence or a considerably lower abundance of all other species (*C. nemoralis* is the only exception) in these two deeply changed biocenoses indicates the high tolerance of this species to such anthropogenous influences. The high abundance of *C. hortensis* is also due to the elimination of competition of other less tolerant species. This conclusion is supported by some observations in other anthropogenously influenced communities and in urban ecosystems (Šustek 1983a, b) and corresponds the Thienemann's rule.

The transect in Malá Pleš shows that a reservation neighbouring with a clearing and having no shrubs on its margin is capable of keeping uninfluenced faunula only in its interior to which a direct sun light can not reach. However, if such clearing has direct contact with cultural steppe, this zone of influence will be larger due to easier immigration of the species of cultural steppe. On the margin a poor ecotonal community arises, which is derived only from species living there before the neighbouring stand was clearcut. Their abundance is reduced considerably. In the ecotonal zone the migration of forest species into clearing is observable. Besides the penetrating by some species characteristic of cultural steppe starts. It is, however, slow in this case due to the isolation of the clearing from cultural steppe by large forests. Such isolated clearing influences the faunula in the neighbouring forest only on the level of abiotic factors. The extent of the influence of such isolated clearing in the carabids and staphylinids in a forest reservation coincides with the extent of penetration by direct sun light into the stand. So, if the soil surface faunula in a forest should stay uninfluenced by clearcutting in its neighbourhood, the protective zone must be present along its margin. A distinctive border between faunas in the beech stand and in the norway spruce monoculture indicates that it is not essentially important, if such zone is

formed by a segment of a natural geobiocenosis or of an artificial one. In some special cases even an exuberant shrub stratum (or shrub belt along the margin) can fulfill such a role (Šustek 1983c). The minimal width of such a protective zone is a function of the stand height, slope, configuration of the earth surface and of time. It can be estimated according the algorithm given in the appendix. The calculations may be restricted to the time between spring equinox and the begin of December and to the time between 7.00—19.00 h. Out of that time the evaporation from the soil and its warming are not intensiver than during the night (Křečmer, Fojt, 1967). The BASIC program is available from author. When interpreting the results of the calculation and applying them practically, we should consider that the algorithm is based on the study of little moveable animals having high sensitivity towards humidity, light intensity and temperature. It is highly probable that in some other animals the minimum zone will be much wider. Similarly it should be considered that the calculation is based on the study of the rand-effect between a forest and a clearing isolated from continuous surfaces of a cultural steppe by at least 1.5 km wide forest belt. If the clearing has a direct contact with cultural steppe, the penetration by „Kulturfolger“ would be more intensive and the influence extent of the faunula in neighbouring forest would be larger. Its extent, in such case, would be determined more by the movability and by autecological requirements of individual species than exclusively by abiotic factors.

Contrary to their artificial origin, both reservation studied harbour a relatively preserved faunas of carabids and staphylinids. The species spectra in reservations and neighbouring stands of natural character are approximately identical. This fact demonstrates the great importance of the reservations as refugia for original fauna, if a part of a landscape must stay temporary under severe anthropical pressure.

The thinning or incidental yield influence the structure of carabids and staphylinids only during short period. If the clearcutting is excluded, the natural economically exploited forests can offer to a reservation a reliable protection against various anthropogenous influences from the surrounding. An artificial coniferous monoculture is inhabited by structurally rather different faunula from the faunula of a natural forest, but it does not influence it. So the artificial coniferous monocultures are acceptable, too, in the neighbourhood of a forest reservation if the clear cutting is excluded. The clear cutting can not be admitted in the vicinity of a forest reservation having no sufficiently wide protective zone.

## Appendix

The astronomical time in which the Sun starts irradiate directly the interior of a forest is given by the formula

$$t = \frac{A}{15} \pm 12 \text{ [hours]}, \quad (1)$$

where A is azimuth of the stand margin and t is time (fig. 10). If t 7.00 or t 19.00 we may apply these for the calculation or we may consider further



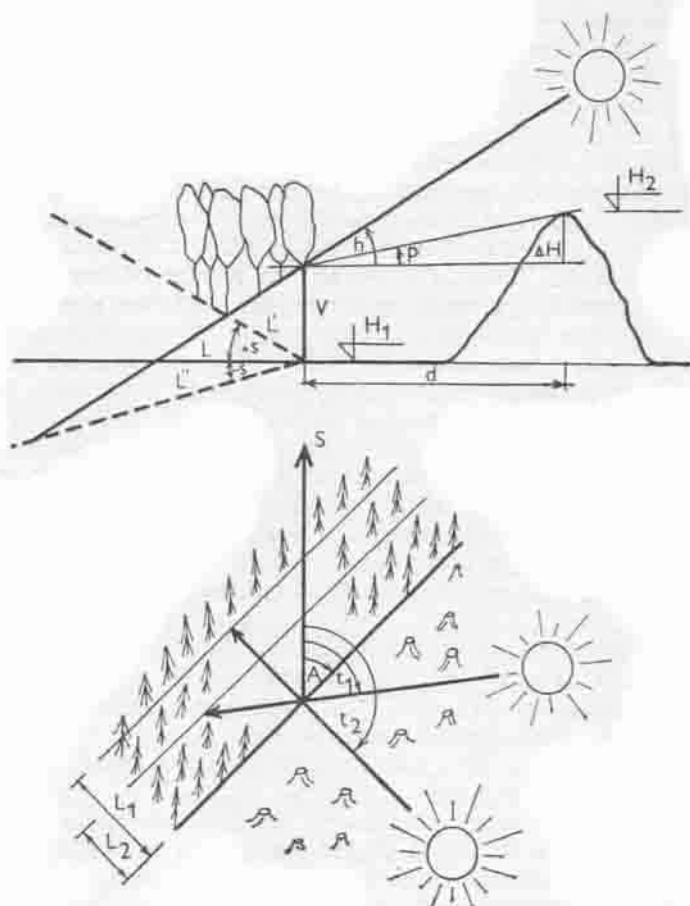


Fig. 10. Depth of the irradiation of a forest in dependence on the configuration of earth's surface, height of the stand and on the orientation of its margin [All symbols see Appendix].

calculation to be unnecessary due to a low evaporation during this time (Krečmer, Fojt, 1967). The day declination of the Sun can be estimated approximately by the formula

$$\sigma = 23.44 \cdot \sin 0.985624 D, [^\circ] \quad (2)$$

where D is number of days between the spring equinox and a required datum and time. The sinus of the Sun height above the horizon is:

$$\sin h = \sin \varphi \cdot \sin \sigma + \cos \varphi \cdot \cos \sigma \cdot \cos (t - 15), \quad (3)$$

where  $\varphi$  is geographical latitude. Let  $H_1$  elevation of stand margin and let  $H_2$  the elevation of an opposite hill, d let a distance between these two places

and v let the height of the basis of the crowns in the trees on the stand margin, then the tangens of the angle limiting the irradiation of the forest is:

$$\operatorname{tg} p = \frac{H_2 - H_1 + v}{d} \left[ \frac{m}{m} \right], \quad (4)$$

then, if the unevenness

$$h - p \geq 0, \quad (5)$$

is not true, the further calculation is not necessary because the stand will not be irradiated directly. If it is true, the minimal width of a protective zone 1 will be:

$$1 = \frac{v \cdot \cos h \cdot \sin [A - 15 t + 180]}{\sin (h + s)} [m], \quad (6)$$

where s is slope (Fig. 10).

Translated by author

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#### CARABIDAE A STAPHYLINIDAE V DVOCH LESNÝCH REZERVÁCIÁCH A ICH REAKCIE NA ĽUDSKÚ ČINNOSŤ V OKOLÍ

Zbyšek Šustek

Holoruby v susedstve lesnej rezervácie hlboko ovplyvňujú faunu v jej vnútri. Rezervácia bukoveho porastu a hospodársky bukovec les prirodzeného charakteru majú približne rovnakú faunu bystruškovitých a drabčíkovitých. Táto reaguje na prebiehajúce kvantitatívne zmeny v jej štruktúre, ale v priebehu jedného roka je schopná vrátiť sa do pôvodného stavu. Hranica medzi prirodzeným bukovým porastom a smrekovou monokultúrou je veľmi ostrá. Vzájomný vplyv faun obidvoch porastov však nie je významný. Preto pri predpoklade, že sa vylúči možnosť holoruby, sú prirodzený bukovec porast aj umelá smreková monokultúra vhodné ako súčasť ochrannej zóny okolo lesnej rezervácie. Takáto, dostatočne široká ochranná zóna je nevyhnutná, ak majú byť porasty v susedstve lesnej rezervácie vyrábané naholo. Uvádza sa spôsob približného určenia šírky takejto zóny.

Došlo 15. 6. 1983

#### CARABIDAE И STAPHYLINIDAE В ДВУХ ЛЕСНЫХ ЗАПОВЕДНИКАХ И ИХ РЕАКЦИИ НА ДЕЯТЕЛЬНОСТЬ ЧЕЛОВЕКА В ОКРЕСТНОСТИ

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Сплошные рубки в соседстве лесного заповедника глубоко влияют на фауну внутри этого заповедника. Заповедник букового насаждения и хозяйственный буковый лес естественного характера имеют приблизительно одинаковую фауну жуков и коротконадкрылых жуков. Эта фауна реагирует на перемены количественными изменениями в ее структуре, но в течение одного года она является способной вернуться в первичное состояние. Граница между естественным буковым насаждением и еловой монокультурой является очень острой. Взаимное влияние фаун обоих насаждений, впрочем, незначительное. Поэтому, при условиях, когда исключается возможность сплошной рубки, естественное буковое насаждение и искусственная еловая монокультура могут быть использованы в качестве составной части защитной зоны около лесного заповедника. Такова, достаточно широкая защитная зона является необходимой, если насаждения в соседстве лесного заповедника должны быть сплошно вырублены. Приводится способ приблизительного установления ширины такой зоны.